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DRAFT CLAUSES

CONCRETE AND CONCRETE MATERIALS

for incorporation in

CSA STANDARD

for

OFFSHORE CONCRETE STRUCTURES

Submitted by: Subcommittee on Materials

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1. MATERIALS

1.1 SCOPE

1.1.1 This standard covers materials to be used and methods to be followed for proportioning, manufacturing, transporting, placing, finishing, curing, protecting and acceptance of concrete, together with requirements for the forming and setting of reinforcing and prestressing steel for offshore concrete structures.

1.1.2 This publication refers to the following and where such reference is made it shall be to that edition of such publications as listed below, including subsequent revisions up to the date of reaffirmations or amendments when so indicated herein:

CSA Standards

CAN3-A5-M77
Portland Cements

CAN3-A23.1-M77
Concrete Materials and Methods of Concrete Construction

CAN3-A23.2-M77
Methods of Test for Concrete

CAN3-A23.5-M82
Supplementary Cementing Materials and Their Use in Concrete construction

CAN3-A362-M82
Blended Hydrdaulic Cements

CAN3-A266.1-M78
Air-Entraining Admixtures for Concrete

CAN3-A266.2-M78
Chemical Admixtures for Concrete

CAN3-A266.4-M78
Guidelines for the Use of Admixtures in Concrete

CSA Preliminary Standard A266.5-M81
Guidelines for the Use of Superplasticizers in Concrete

CAN3-N287.2-M82
Material Requirement for Concrete Containment Structures for CANDU Nuclear Power Plants

CSA Standard G30.16-M77
Welding of Reinforcing Bars in Reinforced Concrete Construction.

CSA Standard G279-M82
Steel for Prestressing Concrete Tendons.

ASTM Standards
A775-81
Epoxy-Coated Reinforcing Steel Bars

C277-81
Potential Alkali Reaction of Cement-Aggregate Combinations

C457-82
Microscopic Determination of Air-Void Parameters of the Air-Void Systems in Hardened Concrete.

D3963-82
Epoxy-Coated Reinforcing Steel

1.2 MATERIALS

1.2.1 CEMENTS AND CEMENTITIOUS MATERIAL

1.2.1.1 Portland cement shall conform to Type 10, 20, 30, 40 or 50

Portland cements in accordance with CSA Standard CAN3-A5 Portland cements.

1.2.1.2 Blended hydraulic cements shall conform to 10S, 10SM or 10P in accordance with CSA Standard with CAN3-A362, Blended Hydraulic Cements.

1.2.1.3 Where natural pozzolans, fly ash, condensed silica fume, pelletized/granulated slag are added at the mixing plant to supplement Portland cement in the concrete, they shall be in accordance with CSA Standard CAN3-A23.5, Supplementary Cementing Materials and Their Use in Concrete Construction.

1.2.1.4 All natural pozzolans, fly ash, condensed silica fume and pelletized/granuldated slag from a particular plant or source must have shown prior satisfactory performances in sea water when used in a similar concrete mixture for marine structures or have shown satisfactory performance in a long-term marine exposure test.

1,2.1.5 The tricalcium aluminate content shall not be less than 3 percent nor greater than 12 percent when calculated on the bases of total cementitious materials used.

NOTE: When oil containing soluable sulfate and soluable sulfides are to be in contact with concrete, specific tests shall be conducted to identify types of cements to use and the mix proportions necessary to resist deterioration.

1.2.1.6 High alumina cement shall not be used.

1.2.2 WATER

1.2.2.1 Water for use in Portland cement concrete and for curing shall

be potable. Sea water shall not be used for mixing or curing concrete.

1.2.2.2 The corrosion-inducing chemicals in the water shall be kept as low as possible and when included in the calculations of the totals of these chemicals in the fresh concrete. The amount of these chemicals shall not exceed the limits set in Clause 1.4.11

1.2.3 AGGREGATES

1.2.3.1 All aggregates shall conform to CSA Standard CAN3-A23.1, Concrete Materials and Methods of Concrete Construction.

1.2.3.2 Aggregates shall be tested for potential alkali aggregate reaction. Concrete prisms shall be made using the proposed materials and tested according to CAN3-A23.2-24A, Alkali Aggregate Reaction. Also mortar bars shall be made and tested according to ASTM Standard C227, Potential Alkali Reaction of Cement Aggregate Combination. In addition the aggregates shall be tested according to CAN3-A23.2-15A, Petrographic Examination for Concrete. Based on the above and after 180 days most curing aggregate undergoing physical or chemical changes or reacting with the cement so as to produce expansion shall not be used unless considerable past experience with concrete products made from cement and aggregates from the same sources have performed satisfactory in a similar exposure condition.

1.2.3.3 Marine aggregates may be used when they have been washed so that the total content of the corrosion inducing chemicals in the concrete mix does not exceed the limits set in Clause

1.4.1.

1.2.4 ADMIXTURES

1.2.4.1 All admixtures shall conform to CSA Standard CAN3-266.1, Air-Entraining Admixtures for Concreted CSA Standard CAN3-A266.2 Chemical Admixtures for Concrete; CSA Standard CAN3-A266.4 Guidelines for the Use of Admixtures in Concrete and CSA Preliminary Standard A266.5, Guidelines for the Use of Superplasticizing Admixtures in concrete.

1.2.4.2 The corrosion-inducing chemicals in the admixtures shall be kept as low as possible and shall be included in the calculations of the totals of these chemicals in the fresh concrete and shall not exceed the limits set in Clause 1.4.1. Calcium chloride shall not be used as an admixture.

1.2.4.3 High range water reducers (superplasticizers) shall be used where a high degree of workability is required in concrete. NOTE: High range water reducers (superplasticizers) should be considered for concrete where slumps in excess of 150 mm are required.

1.2.5 REINFORCING STEEL

1.2.5.1 All reinforcing steel shall conform to CSA Standard G30.16, Weldable Low Alloy Steel Bars Deformed Bars for Concrete Reinforcement. When requested by the designer, data covering the relevant temperature range shall be submitted on impact, relaxation and fatigue properties where these loads are of concern.

1.2.5.2 Splicing of reinforcing bars by welding shall conform to the

requirements of CSA Standard W186, Welding of Reinforcing Bars in Reinforced Concrete.

1.2.5.3 In areas where deicing agents will be used or in applications where corrosive liquids can migrate through concrete sections and then concentrate through evaporation, all reinforcing shall be coated with epoxy. The epoxy coated bar shall comply with ASTM Standard A775, Epoxy-Coated Reinforcing Steel Bars and ASTM Standard D3963 Epoxy-Coated Reinforcing Steel.

1.2.5.4 When Mechanical Splices are used they shall comply with Clauses 5.7 and 5.8 of CSA Standard CAN3-N287.2, Material Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants.

1.2.6 PRESTRESSING STEEL

1.2.6.1 All prestressing steel shall conform to CSA Standard G279, Steel for Prestressing Concrete Tendons.

1.2.6.2 Anchorage, Coupling Anchorages, and Anchorage Components shall meet the requirements of Clauses 6.3 and 6.4 of CSA Standard CAN3-N287, Material Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants.When requested by the designer data covering the relevant temperature ranges on impact, relaxation and fatigue properties shall be submitted for prestressing steel, tendon-anchorage assemblies and couplers where these types of loading are of concern.

1.2.6.3 All metal sheathing and prestressing steel shall be stored

clear of the ground and protected from the weather, especially from moisture from the ground, sea spray and mist. Plastic sheaths shall not be used.

1.2.7 GROUT FOR POSTENSIONED TENDONS

1.2.7.1 Grout shall be in accordance with CSA Standard CAN3-A23.1 Section 26.3.

1.2.7.2 The minimum compressive strength of the grout at 28 days shall be 30 MPa, when tested in accordance with CSA Test Method A23.2-1B.

1.2.7.3 The water to cement ratio shall be the minimum necessary for proper placement, but shall not exceed 0.50.

1.2.7.4 In grouting of long vertical tendons, where previous experience is limited, full size procedural qualification test shall be done to verify the adequacy of the grout mix and the grouting procedure.

1.2.7.5 Only air entrained expansive grout shall be used. Grout shall expand from 4 to 8 percent and contain 5 to 8 percent total air. The maximum time between mixing and pumping of grout is to be such that expansion of the grout takes place after injection. Until injected, the grout shall be continuously agitated.

1.2.7.6 Grouts shall not be warmer than 25°C or colder than 10°C during mixing and pumping. During grouting and the first two days thereafter the temperature in the structure is not to fall below +5°C.

1.3 CONCRETE, STRENGTH AND PERMEABILITY

1.3.1 The maximum water-cement ratio, minimum quantity of

cementitious material, minimum compressive strengths and maximum permeability shall be as given in Table 1.1.

1.4 CORROSION-INDUCING CHEMICALS

1.4.1 The concentration of corrosion-inducing chemicals from all sources in the concrete prior to exposure shall be kept as low as is reasonably possible and shall not exceed the following limits:

(a) Chlorides (water soluable) 0.10% by weight of cement

(b) Fluorides (water soluable) 0.10% by weight of cement

(c) Sulphites (water soluable) 0.13% by weight of cement

(d) Nitrates (water soluable) 0.17% by weight of cement

The concentration of the above corrosion-inducing chemicals shall not exceed 60% of the above limits for prestressed concrete and shall not exceed 25% of the above limits for grout.

1.4.2 The concentration of corrosion inducing chemicals shall be determined by the following:

Chemical	ASTM Standard	Name
Chlorides	D512-81	Chloride Ion in Water
Fluorides	D1179-80	Fluoride Ion in Water
Sulphites	D1339-84	Sulfite Ion in Water
Nitrates	D3867-79	Nitrite-Nitrate in Water

1.5 ABRASION RESISTANCE

1.5.1 If severe scouring action due to pebbles, sand, silt or ice is

TABLE 1.1

MIX PROPORTIONS AND CONCRETE PROPERTIES

Zone*	Maximum W/C Ratio	Minimum Quantity ** Of Cementitious Material in kg/m³	Minimum Compressive Strength † MPa		Maximum Permeability *** in m/s at 90 days
			28 days	90 days	
Submerged	0.45	360	30	35	2.5×10^{-13}
Splash	0.40	400	35	37.5	2×10^{-13}
Atmospheric	0.40	400	35	37.5	2×10^{-13}

† Designer may choose later age acceptance.

* The submerged zone is considered to be 1 meter below the lowest water level reached by a wave with a statistical return period of six months, when superimposed on the lowest level of spring tide.

** Values listed are when 20 mm maximum size aggregate is used. When 40 mm maximum size aggregate is used then the minimum cement content can be reduced by 40 kg/m³.

*** Permeability shall be measured using the device developed by CANMET and described in the paper, The Measurement of Concrete Permeability by Brian B. Hope and V. Mohan Malhotra, Canadian Journal of Civil Engineering, Vol. 11, No. 2, June 1984, pp. 287-292.

expected, the coarse aggregate used in the concrete shall be at lease as hard as the material causing abrasion. The concrete compressive strength at 28 days shall be 40 MPa in the zone where abrasion will occur.

1.6 THERMAL CRACK CONTROL

1.6.1 Thermal Cracking from strains resulting from the heat of hydration can increase the permeability of the concrete. To minimize these cracks when the minimum dimension of concrete to be placed at one time is greater than 600 mm and where the cement content is more than 400 kg/m^3, the use of cement with a low heat of hydration (CSA Type 40) or other such action to reduce the temperature shall be employed. Methods may include cooling mix water or use of insulation to reduce thermal gradients. Because the high thermal resistance of lightweight concrete will accentuate this problem, precautions may be required for lightweight concrete sections greater than 400 mm.

1.7 FREEZING AND THAWING

1.7.1 The total air content of the concrete at the time of placing shall be within the following range:

Nominal Size of Aggregate mm	Range of Total Air Content in Percent
10	7-10
14	6-9
20	5-8
40	4-7

Tests shall be done to determine the air void system in concrete produced with the proposed materials and mixing system. A minimum surface area of 25 mm^2/mm^3 and maximum

spacing factor of 0.2mm shall be produced when tested according to ASTM Standard C457, Microscopic Determination of Air-Void Content or Parameters of the Air-Void System in Hardened Concrete.

1.7.2 All concrete made from lightweight aggregates shall be allowed to dry to a moisture content below the critical degree of saturation prior to being exposed to freezing and thawing.

1.8 CONCRETE PROTECTION OF REINFORCEMENT

1.8.1 Concrete cover shall be measured from the concrete surface to the nearest deformation (or surface of a smooth bar, wire to duct) of the reinforcing steel and be a minimum of 75 mm of concrete in the splash zone and in the atmospheric zone and a minimum of 60 mm of concrete in the submerged zone. These values shall be increased to 100 mm and 75 mm respectively for prestressing wires and post-tensioning ducts.